



Tracheostomy: update on why, when and how

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Purpose of review

The aim of this review is to summarize available data, including the most recent ones, to help develop the best possible strategy regarding the use of tracheostomy in ICU patients requiring prolonged mechanical ventilation or who experience loss of airway-protecting mechanisms.

Recent findings

Tracheostomy facilitates the weaning process by reducing the patient's work of breathing and increasing comfort. It thus allows for a reduction in sedation levels. It also helps with secretions clearance, facilitates disconnection from the ventilator, and enables earlier phonation, oral intake, and mobilization. Despite these advantages, tracheostomy does not reduce mortality and is associated with both early and late complications, particularly tracheal stenosis. The timing of tracheostomy remains a subject of debate, and only a personalized approach that considers each patient's specific characteristics can help find the best possible compromise between avoiding unnecessary delays and minimizing the risks of performing a needless invasive procedure. In the absence of contraindications, the percutaneous single dilator technique under fibroscopic guidance should be the first choice, but only if the team is properly trained.

Summary

A step-by-step individualized approach based on the available evidence allows identifying the best strategy regarding the use of tracheostomy in ICU patients.

Video abstract

<http://links.lww.com/COCC/A56>.

Keywords

clinical outcomes, percutaneous technique, timing, tracheostomy, weaning

INTRODUCTION

Tracheostomy is commonly performed in intensive care unit (ICU) patients [1], particularly when weaning from mechanical ventilation is not easy [2,3]. Two large cohorts of invasively ventilated patients have shown that nearly 5% of all invasively ventilated ICU patients [2] and 19.6% of those ventilated for at least 48 h [3] underwent tracheostomy at some point during their ICU stay. Among patients with acute respiratory distress syndrome (ARDS) worldwide, 13% underwent tracheostomy, with a median of 14 days after ARDS onset [4]. The prevalence of the procedure was higher in high-income European countries, reflecting differences in local medical practices, expertise, and resources [4]. Despite its common use in the ICU, the indications and utility of tracheostomy remain debated [5], with many potential advantages not confirmed in randomized trials, leading to a lack of clear guidelines on its necessity or optimal timing in critically ill patients.

The aim of this review article is to summarize the available data, including the most recent findings,

to help develop the best possible strategy for the use of tracheostomy in ICU patients experiencing prolonged mechanical ventilation and/or loss of airway-protective mechanisms.

Advantages and risks of tracheostomy

In the ICU, the most frequent reasons for performing a tracheostomy as an alternative to prolonged translaryngeal intubation are to reduce the risk of laryngeal injuries and to improve patient comfort [6].

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KEY POINTS

- Tracheostomy is frequently performed in ICU patients, but its indications, utility and timing remain debated.
- Tracheostomy facilitates weaning, reduces the duration of mechanical ventilation, the need for sedation and increases patient comfort. However, it does not decrease mortality.
- Only a personalized approach that considers each patient's specific characteristics can help find the best possible compromise between avoiding unnecessary delays and minimizing the risks of performing a needless procedure.
- In the absence of contraindications, percutaneous single dilator technique under fibroscopic guidance should be the strategy of choice to perform a tracheostomy.

Vocal cord oedema and damage, laryngeal erosions, granulations and stenosis can develop after just a few days of intubation and become more frequent and severe with prolonged intubation [7]. Although these alterations are usually reversible and gradually improve after tube removal, irreversible lesions with permanent disability can occur, even with the use of high-volume low-pressure cuffs [7,8]. The morphological changes of the larynx and/or unilateral vocal cord paralysis increase the risk of aspiration and subsequent pneumonia after extubation, and can lead to pain, dysphonia, dysphagia and, less frequently, to stridor and dyspnoea [7,9]. Although tracheostomy itself can cause tracheal lesions, particularly stenosis [6,10–14], it offers benefits such as improved patient comfort and reduced need for intravenous sedation and analgesia [15,16]. This is crucial in prolonged weaning since the level of sedation is the only modifiable factor that has been associated with the duration of weaning from mechanical ventilation [3]. Additionally, reducing the level of sedation facilitates communication with patients, thereby aiding treatment [17]. Furthermore, placing a tracheostomy facilitates early mobilization, which may improve the functional outcomes of patients undergoing prolonged mechanical ventilation [18].

Placing a tracheostomy provides a more stable and secure airway, with easier tube reinsertion once the stoma tract has matured (typically after 3–7 days) and decreases incidence of inadvertent decannulation compared to accidental extubation [6,19]. However, when airway accidents related to tracheostomy occur, severe consequences and even death have been reported [6,20]. Compared to a translaryngeal tube, tracheostomy facilitates

suctioning, secretion removal, and buccopharyngeal hygiene [6,17], potentially reducing the incidence of ventilator associated pneumonia (VAP) [5,21]. Data on this topic is however controversial [21–23]. Coming back to weaning from mechanical ventilation, tracheostomy offers physiological advantages that can ease the process. In vitro, the resistance of a tracheostomy cannula has been found to be lower compared to a same inner diameter endotracheal tube [24]. In a small physiological study, Diehl *et al.* demonstrated that replacing the endotracheal tube with a tracheostomy cannula of the same inner diameter allowed for the reduction of intrinsic positive end-expiratory pressure (PEEP), work of breathing (WOB) – an index of effort generated by the inspiratory muscles to ensure airflow into the lungs [25]–and respiratory drive, the neural command of breathing [24]. Compared to spontaneous breathing after extubation, bypassing the upper airways with a tracheostomy decreases anatomical dead space by up to 76–100 ml [26,27], increasing breathing efficiency by reducing the dead space ventilation to total minute ventilation ratio. This allows reducing the WOB needed to maintain normoxia and normocapnia. As failure to wean often results from an imbalance between reduced respiratory muscle capacity due to acquired muscle weakness [28] and increased WOB [29], reducing WOB by placing a tracheostomy cannula may facilitate weaning. Additionally, a tracheostomy further aids the weaning process by simplifying disconnection from the ventilator and reconnection when needed, making it easier to manage compared to extubation failure [30].

Regarding the risks, tracheostomy remains an invasive procedure that can lead to both periprocedural and later complications [13,14]. Although the most frequent complications are typically minor, rare but life-threatening issues can occur such as severe vascular lesions leading to serious haemorrhages or cannula obstruction leading to severe desaturation, and even unexpected cardio-respiratory arrest [5]. Clinicians should be aware that secretions may slowly and insidiously accumulate in the inner cannula, necessitating close monitoring of the tracheostomized patients. This is particularly important when a patient with a tracheostomy is transferred to a lower-level care area. In a prospective observational cohort study, Martinez *et al.* reported that patients discharged to the ward with a tracheostomy in place tended to have increased mortality compared to those who had been decannulated before leaving the ICU [31,32]. This was not, however, found in other studies especially when a dedicated team was available in the ward [33]. Overall, at least one complication related to tracheostomy was

recently reported in 10.3% of US tracheostomized patients, with the highest incidence among patients with more comorbidities [34^{***}]. Specifically, adverse events associated with tracheostomy include periprocedural bleeding, stoma infection, pneumothorax, transient desaturation, loss of airway control up to cardiorespiratory arrest, tracheal wall rupture, tracheoesophageal fistula, vascular erosion of the innominate artery, granular tissue formation, tracheal narrowing, and disfiguring scars [7,19,20,22,34^{***}]. Special attention should be given to tracheal stenosis and its recent increase in incidence following the COVID-19 pandemic [10,11]. Numerous cases of severe and symptomatic tracheal narrowing requiring interventional treatment have been described, with correlations noted not only with the use of a tracheostomy cannula but also with the duration of intubation prior to tracheostomy [10–12,14].

Tracheostomy and outcomes

Regarding the outcomes of tracheostomized patients, both a meta-analysis of randomized or quasi-randomized trials conducted by Griffiths *et al.* [23] and a large prospective randomized study [35] comparing early versus later tracheostomy or prolonged endotracheal intubation showed that earlier tracheostomy reduced duration of mechanical ventilation, confirming that tracheostomy facilitates the weaning process. Despite this and the other potential advantages of tracheostomy mentioned above, tracheostomized patients generally experience prolonged ICU and hospital stays. Their mortality rate is high, reaching up to 29% at hospital discharge and as much as 50% one year after discharge. Additionally, survivors often face impaired functional outcomes and frequent hospital readmissions [1,36,37].

Compared to nontracheostomized patients, ARDS patients who underwent tracheostomy had lower 28-day mortality, but the overall survival benefit at 60 and 90 days was not confirmed in subgroup analyses designed to reduce bias and match patients [4]. In various other cohorts and studies on more general populations, tracheostomy prolonged short-term survival but did not favourably impact long-term outcomes [5,35,38,39]. Importantly, however, the large TrachMan randomized study [35] found no increase in mortality among patients expected to require more than 14 days of intubation who were randomized to receive an early tracheostomy (within 4 days after intubation), compared to those randomized to receive a tracheostomy after at least 10 days of intubation, many of whom were never tracheostomized [35].

Timing of tracheostomy

Tracheostomy facilitates the care of patients requiring prolonged mechanical ventilation and/or lower airway protection and should be considered for these individuals. It may also improve important patient-centred outcomes, such as speaking, eating, and drinking, which are crucial for physical and psychological recovery [19], even if often underestimated by physicians [40^{*}]. For example, ICU survivors frequently cite the inability to communicate as one of their most negative experiences [40^{*},41]. Since tracheostomy enables quicker resumption of oral communication and intake [15], it should clearly be considered to avoid prolonged translaryngeal intubation, as long as the risks of both approaches are comparable for a specific patient. However, performing tracheostomy too early in the course of the disease may expose patients to an unnecessary procedure and its associated risks [7,11,12,14,20,34^{***}]. Notably, in the TrachMan study, one of the largest randomized controlled trials comparing the effects of early versus late tracheostomy, 53.7% of the patients randomized to receive late tracheostomy never needed the procedure, as their need for ventilation ended before 10 days of intubation. A similar proportion of patients did not require tracheostomy in the recent retrospective cohort by Zimmerman *et al.* [42].

The timing of tracheostomy remains a debated topic, with no consensus on what defines “early” versus “late” tracheostomy. The meta-analysis by Chorat *et al.* [43], analysed 17 trials (3145 patients) comparing early (<7 days) versus late (>7 days) tracheostomy, and reported lower rates of VAP, shorter durations of mechanical ventilation and ICU stay, but no overall difference in mortality with early tracheostomy. These findings align with an earlier meta-analysis that considered the same timeframes [44]. Two recent retrospective cohorts favoured early tracheostomy, linking it to lower hospital [45] and even 5-year [46] all-cause mortality. It is important to note that the potential impact of early tracheostomy on 5-year mortality was only observed in a propensity score-matched retrospective analysis conducted among the US national veteran population from 1999 to 2022, which compared outcomes between early (<10 days) or late (>10 days from intubation) tracheostomy [46]. Importantly, this potential impact on mortality was not found in the large TrachMan randomized study, in which 909 patients with expected prolonged duration of mechanical ventilation were randomized to receive either a tracheostomy within the 4 days following intubation or after at least 10 days of intubation [35]. In this study, hospital length of stay was also similar in the two groups [35].

Guidelines suggest performing a tracheostomy in critically ill patients who are expected to require prolonged mechanical ventilation and/or who are unable to adequately protect their lower airways due to neurologic impairment, once the initial stabilization phase has concluded [5,21], but not before the 4th day of intubation [5]. Additionally, tracheostomy should only be considered for patients with a realistic potential for survival and favourable outcomes [5]. Close attention should be paid to patients with severe, untreatable preexisting conditions, such as severe chronic obstructive pulmonary disease and amyotrophic lateral sclerosis. In fact, these patients may require permanent home ventilatory support and tracheostomy is not likely to be a temporary measure for them. Multidisciplinary discussions should precede the decision to perform a tracheostomy in this special population, as well as a thorough explanation of its potential long-term consequences (including the life-long requirement for ventilatory support) to the patient, if possible, and his/her family [5]. Sometimes, it may also be considered, for this specific patient population, to proceed with extubation followed by a noninvasive ventilation (NIV) trial.

In practice, the good timing for tracheostomy depends on individual factors like disease, comorbidities, preadmission functional status and expected progression of the acute disease [5]. In ARDS cases, it is common practice to wait 10–14 days before considering a tracheostomy due to the difficulty in predicting the intubation duration early on [19,41]. In other situations, such as severe Guillain Barré syndrome or in some trauma or neurosurgical patients, earlier tracheostomy may be appropriate, if the prognosis is favourable enough [5,21]. Special consideration should be given to COVID-19 patients, as they have generally undergone tracheostomy later compared to the non-COVID population due to prolonged high PEEP requirement that contraindicated tracheostomy placement [47–49]. Although not an absolute contraindication, the prone position prevents visual control of artificial airways, increasing the risk of cannula displacement and pressure ulcers [49]. Furthermore, concerns about aerosol spread during the initial phase of the pandemic led to postponing the procedures [50]. Studies on the optimal timing of tracheostomy in COVID-19 patients are heterogeneous, but overall recommendations should not differ from those for the general population [49,51].

Regardless of the timing, performing a tracheostomy to facilitate mechanical ventilation weaning or care should never be considered an emergency. Ensuring safe conditions for the procedure is mandatory, and contraindications to the procedure, such as severe hypoxemia (e.g. $P/F < 100$ mmHg or

$FIO_2 > 70\%$), need for high PEEP (> 10 cmH₂O), hemodynamic instability, intracranial hypertension, and unreversed bleeding disorder (platelets $< 50\,000 \times 10^9/l$, INR > 1.5 , PTT > 2 times the baseline value or nonsuspension of anticoagulation) must always be taken into account [5,21].

Based on the previous considerations, Fig. 1 summarizes the steps to be considered in the process of deciding for a tracheostomy.

Tracheostomy technique

Guidelines suggest that, whenever possible and in the absence of contraindications, percutaneous tracheostomy (PT) should be the first choice, as it is a safe alternative to the classical surgical procedure (ST) with some advantages [5]. PT can be performed bedside, eliminates the need for an operating room, reduces waiting time and avoids the risks associated with transporting critically ill patients [52,53]. It also requires fewer staff members, although the presence of an ear, nose, and throat surgeon for rapid conversion in case of complications is recommended [5,21,30]. To note, PT seems easier to learn compared to ST. Massick *et al.* report a learning curve of 20 procedures, with a significant reduction in observed complications thereafter [54]. Importantly, both the American College of Chest Physician and the European Respiratory Society recommend a minimum of 10 procedures per year to maintain competency [55]. Clinicians must be aware that even though rare, the complications of PT can be lethal, including airway loss, massive bleeding, pneumothorax, tracheal injury, cannula misplacement, or occlusion [56]. Therefore, ST may still be the preferred choice based on the team's expertise. In addition, ST remains the technique of choice in the most difficult situations as unfavourable neck anatomy, short neck, or morbid obesity. Regarding other potential advantages of PT, some studies suggest a lower rate of wound infection and periprocedural bleeding compared to ST, likely because the percutaneous placement of the cannula allows the stoma to fit snugly around the tracheostomy tube, which helps tamponade bleeding vessels and prevent infection [21,30,52,57,58]. To note, one drawback of PT compared to ST is, however, that changing the cannula is only possible after 7–10 days with PT compared to 4 days with ST [5]. The two techniques have comparable rates of tracheal stenosis [59].

A total of six PT techniques have been described: multiple dilator (Ciaglia), guide wire dilating forceps (Griggs), single dilator (modified Ciaglia or Blue Rhino), rotating dilation (Percutwist), balloon dilation (Blue Dolphin), and translaryngeal (Fantoni) [5]. Among these, the most performed and probably

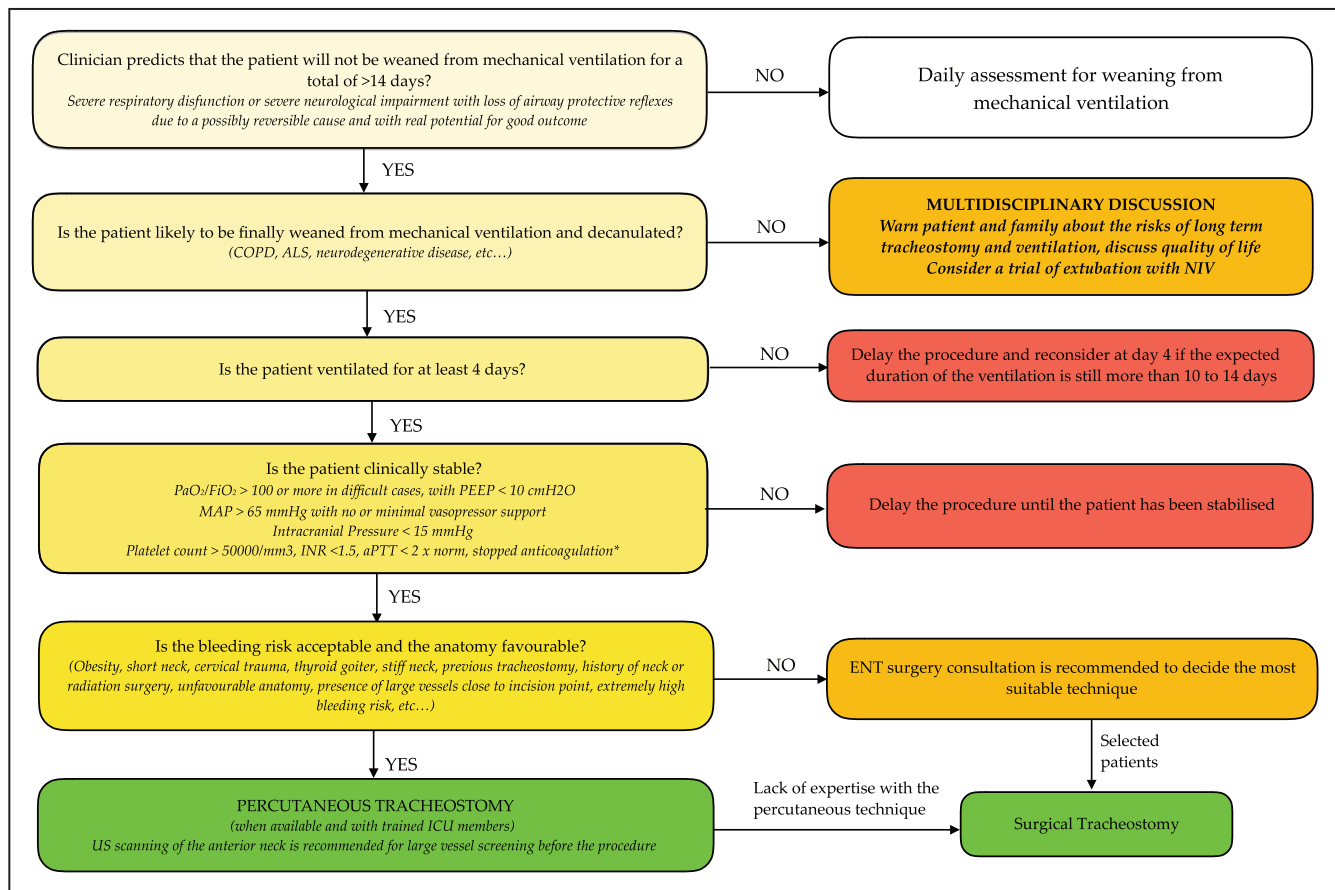


FIGURE 1. Tracheostomy decisional algorithm. COPD, chronic obstructive pulmonary disease; ALS, amyotrophic lateral sclerosis; $\text{PaO}_2/\text{FiO}_2$, arterial partial pressure of oxygen/fraction of inspired oxygen; PEEP, positive end-expiratory pressure; MAP, mean arterial pressure; INR, international normalized ratio; aPTT, activated partial thromboplastin time; ENT, ear, nose and throat (otorhinolaryngology). *Trouillet JL, *et al.* Tracheotomy in the intensive care unit: guidelines from a French expert panel. *Ann Intensive Care* 2018;8.

safest is the single dilator technique [56,59[¶],60]. This technique involves a needle puncture of the anterior trachea, followed by the placement of a guidewire and the subsequent introduction of a single dilator, through which the tracheal opening is progressively enlarged. The dilator is then replaced by the cannula and the guidewire removed [22]. Guidelines recommend the use of ultrasound for large vessel scanning of the neck prior to puncture to reduce the risk of major bleeding and to help identify anatomical landmarks in obese patients [5,59[¶]]. The tracheostomy procedure should be performed under fibroscopic guidance to reduce the risk of tracheal rupture and inadvertent extubation [61].

Early during the COVID-19 pandemic, ST was considered safer for healthcare personnel as it required fewer ventilator circuit openings, thereby reducing the likelihood of aerosol spread. It was also deemed safer for patients due to the electrocauterization, which could help control the increased bleeding risk related to the disease related

coagulation alteration [49]. However, studies demonstrated the safety of PT for both patients and healthcare providers also in COVID-19 [47,62].

CONCLUSION

Tracheostomy is often performed in ICU patients requiring prolonged intubation or who are unable to protect their lower airways. Although it does not reduce mortality, tracheostomy may help in weaning critically ill patients from mechanical ventilation, reduces the need for sedation and improve patient comfort. The timing of tracheostomy remains a subject of debate, and only a personalized approach that considers each patient's specific characteristics can help find the best possible compromise between avoiding unnecessary delays and minimizing the risks of performing a needless procedure. In the absence of contraindications, percutaneous single dilator technique under fibroscopic guidance should be the strategy of choice.

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Conflicts of interest

There are no conflicts of interest.

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- of special interest
- of outstanding interest

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